

# UNCERTAINTY QUANTIFICATION IN ANALYSIS AND DESIGN OF STOCHASTIC CONTINUUM SYSTEMS

**N. Zabaras<sup>a</sup> and V. Asokan Badri Narayanan<sup>b</sup>**

Materials Process Design and Control Laboratory  
Sibley School of Mechanical and Aerospace Engineering  
188 Frank H. T. Rhodes Hall  
Cornell University  
Ithaca, NY 14853-3801

<sup>a</sup>zabaras@cornell.edu, <sup>b</sup>bnv2@cornell.edu

A spectral stochastic finite element approach (SSFEM) is considered to investigate the propagation of uncertainty in the direct and inverse-design analysis of convection/diffusion systems. Randomness is considered as an additional dimension to that of space and time. Uncertainty quantification is performed by introducing a functional space with an associated stochastic dimension. Each stochastic process is represented in series form as the sum of its projections onto a trial basis of orthogonal polynomials that span the probability space. Stabilization techniques developed for FEM analysis of deterministic convection dominated problems would be extended to address stochastic systems. A parametric study of the direct analysis is conducted to investigate the propagation of uncertainty in the material data or process conditions to the thermal and/or flow response fields. In addition, convergence tests were conducted to study the effect of the number of terms in the spectral series representation of the computed stochastic processes.

An investigation will also be presented of the application of the SSFEM in the solution of a class of stochastic inverse/design convection/diffusion problems. Starting with desired robustness limits on the temperature field within parts of the boundary or the domain, we will show how we can compute the full statistics of the required boundary heat flux (here taken as the stochastic design variable). An iterative technique is developed using optimization techniques in an appropriate infinite-dimensional function space. Both one- and two-dimensional design examples will be addressed to investigate the propagation of uncertainty in such inverse design problems. Finally, we would conclude with a discussion on future potential and scope for research in computational robust design of stochastic continuum systems.